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AIR BEARING TYPE WORK HOLDER

Inventors:

Koji Kawaguchi
Hitachi Ltd., Central Laboratories
1-280 Higashi Koigakubo, Kokubunji-shi, Tokyo

Takeji Shiokawa
Hitachi Ltd., Central Laboratories
1-280 Higashi Koigakubo, Kokubunji-shi, Tokyo

Kuniyoshi Imai
Hitachi Ltd., Central Laboratories
1-280 Higashi Koigakubo, Kokubunji-shi, Tokyo

Toshimitsu Miyata
Hitachi Ltd., Central Laboratories
1-280 Higashi Koigakubo, Kokubunji-shi, Tokyo

Kenji Morita
Hitachi Ltd., Central Laboratories
1-280 Higashi Koigakubo, Kokubunji-shi, Tokyo

Hideo Kashima
Hitachi Ltd., Central Laboratories
1-280 Higashi Koigakubo, Kokubunji-shi, Tokyo

Applicant: Hitachi Ltd.
4-6 Surugadai, Kanda, Chiyoda-ku, Tokyo

Agent: Katsuo Ogawa, patent attorney, and one other

[There are no amendments to this patent.]

Claims

1. An air bearing type work holder with which high speed grinding is carried out by putting a grinding liquid between the workpiece and the faceplate, characterized in that it is constructed so that a rotational drive shaft and a work guide, which holds the workpiece placed on the rotating faceplate under pressure, are joined by means of a bellows coupling and are supported by a bearing which uses air as its medium.

2. The air bearing type work holder of Claim 1, characterized in that it is constructed so that processing adjustments on the above-mentioned workpiece are made by enclosing part of the above-mentioned air inside the above-mentioned bellows coupling.

3. The air bearing type work holder of Claim 1, characterized in that it is constructed so that processing adjustments on the above-mentioned workpiece are made by fitting an air cylinder, which introduces part of the above-mentioned air onto the work guide or the work shaft, which supports the workpiece.

4. The air bearing type work holder of Claim 1, characterized in that the above-mentioned work is being constructed so that multiple workpieces which have different processing heights are processed with varying pressures by introduction of the above-mentioned air.

Detailed explanation of the invention

Industrial application field

The present invention pertains to flow trap devices, and in particular, it pertains to air bearing type work holders for float polishing which polish work surfaces with a high degree of surface precision.

Prior art

In areas related to semiconductors, the growing demand and the rationalizing of production and assembly of high value-added products are being attempted, and the demand for high efficiency and high precision in the grinding process, which is the final finishing process of the part, has greatly increased, and in particular, research and development of mirror surface processing technologies is being rapidly advanced.

Float polishing is a polishing method in which a work holder, which is processed into a flat surface of high precision (hereafter called the faceplate), is rotated under conditions in which absolutely no misalignment of the surface will occur, a grinding liquid is applied to it as a liquid film and the workpiece (hereafter called the workpiece) is pressed onto it. There is a spiral-shaped groove on the faceplate, and when the faceplate and the workpiece are rotated at high speed, through the dynamic fluid pressure lubricating state of the grinding liquid, these two are ground without touching each other. In this case, if the workpiece is first finished to a mirror surface, it is possible to maintain a noncontacting state, and as finish

grinding, it is possible to transfer the flat surface of the faceplate to the workpiece. The state of the grinding is determined by the relationship of the faceplate to the workpiece, which is largely divided into (a) grinding with direct contact, (b) grinding with partial contact and (c) grinding with no contact, and most of the grinding will fall into one of these categories.

The air bearing type work holder does not simply maintain one of these grinding states, but is a grinding device which is based on selectively changing the grinding state and carrying out a process which involves a mechanical action, a chemical action or a physical chemical action. For example, during the initial state of grinding, through the mechanical effect of rubbing the workpiece on the faceplate, a flat mirror surface is obtained, and by putting these two in a noncontacting state during the latter half of the grinding, it is possible to create a process in which an smooth surface without processing defects is ensured through the etching effect of the grinding liquid. At this time, it is necessary to increase the processing accuracy or processing capability by changing the contact state of the workpiece and the faceplate gradually, or by alternately changing it, and as a result, it is desirable for the workpiece which is pressed against the faceplate to be effectively adjusted for pressure.

One example of a method using a previous technology will be explained through the diagrams. Figure 4 shows a cross section of a previous work holder.

A slot (33) is opened in the work shaft (32) to which the workpiece (50) is fixed, a pin (34) is passed through it, and the pin (34) and the work shaft holder (35) are fixed together. Also, the work shaft holder (35) holds the work shaft (32) by means of

two linear motion bearings (36). Through the above structure, while the rotational force is transmitted from the rotational drive shaft (2) to the work shaft (32), at the same time, the vertical motion of the workpiece (50) with respect to the faceplate (28) is also possible. The upper part of the workpiece (50) is constructed with a weight (37) attached in order to increase the pressure against the workpiece (50). Also, this example is proposed in "Porishingu kiko [Polishing devices]" issued as the proceedings of a research seminar by the Nihon Association for the Advancement of Science (p. 52, Figure 12).

Problems to be solved by the invention

The above-mentioned technologies are not applicable to flat surface grinding which require a high surface precision on the order of Å because there are inadequate safeguards against misalignment of the centers of rotation, or angular errors. Also, unless the movement was stopped, the weight could be replaced, and there were numerous problems when the pressure on the workpiece was gradually changed, or it was alternately changed, requiring large amounts of time and labor.

The objective of the present invention is to solve the above-mentioned problems, and to grind a workpiece effectively with a high degree of surface precision.

Mean top solve the problems

The above-mentioned objective is achieved by joining a work guide constructed so that it can be supported by air bearings, and a rotational drive shaft through a bellows coupling, and when

needed, fastening the workpiece under air pressure. In other words, it involves directly connecting the bellows coupling or an air cylinder to the workpiece pressure unit.

Function

The bellows coupling transfers the rotational force of the rotational drive shaft to the work guide, and it can also easily expand and contract in a vertical direction. As a result, the work guide can rotate while changing directions, and the work face will rotate according to the upper surface of the faceplate.

Also, by adjusting the outlet air flow pressure, the air pressure of the bellows coupling or air cylinder is adjusted, and it is possible to modulate the pressure of the work guide.

Application examples

Application examples of the present invention will be explained below through the diagrams.

Application Example 1

Figure 1 is a diagram which shows a cross-section of an application example of the air bearing type work holder of the present invention.

This mechanism is composed of an air pressure induction unit (1), a rotational drive shaft (2), a guide ring (3), a work guide (4), etc. Air pockets (5), (6), (7), (8) (with a clearance of 0.02 mm) which form the air bearings are formed between the air pressure introduction unit (1) and the rotational drive shaft (2)

and between the guide ring (3) and the work guide (4), and the rotational drive shaft (2) and the guide ring (3) are joined by the bellows coupling (9).

An air pressure introduction inlet (10), a relay opening (11) and a pressure control opening (12) are fitted to the air pressure introduction unit (1). A tube (16) and a coupling (13) are attached to the air induction inlet (10), and the air which is delivered from the air supply source (15) is introduced to the air pressure induction inlet (10) through the tube (16) and the coupling (13).

The air which is enclosed is expelled to the outside of the mechanism through the paths indicated by arrows (a), (b), (c) by way of the air pockets (5).

A coupling (19), a tube (17), a pressure gauge (38) and a speed controller (42) are placed in order in the pressure control opening (12), and the air which is channeled into the path indicated by arrow (d) is expelled to the outside therethrough.

Several workpieces (50) which are to be ground are fixed by adhesion to the bottom of the work guide (4), and a pin (25) is attached to the work guide (4) and the guide ring (3) for the purpose of transmitting the rotational force and for positioning. In addition, an O-ring (26) is attached to the pin (25) so that there will not be any metal-on-metal rubbing during rotation. Therefore the guide ring (3) and the work guide (4) rotate at the same time, and because the work guide (4) serves as an air bearing guide, vertical movement along the guide ring (3) is easily achieved.

Although its design is not explained here, a rotational drive unit (27) is fitted to the upper part of the rotational drive shaft (2), and the rotational drive unit (27) and the

rotational drive shaft (2) are completely joined. As a result, the rotational drive shaft (2) rotates due to the rotational force transmitted from the rotational drive unit (27).

Air is introduced into the air pressure induction inlet (10) before rotation, and as explained previously, because the air pressure induction unit (1) and the rotational drive shaft (2) are not in contact, the rotational force is not transferred to the air pressure induction unit (1). Therefore, the rotational force is suppressed by the tube (16) and the air pressure induction unit (1) will not turn. The rotational force transmitted from the rotational drive shaft (2) is transmitted along the bellows coupling (9) to the work guide (4), and the rotational force is also transmitted to the guide ring (3) through the pin (25). In other words, only the air pressure induction unit (1) is in a fixed state and all of the other components which rotate on top of the rotating face plate (28) will turn. Because the face plate (28) is also rotating, an arm (30), which holds two ball bearings (29), is placed from one part of the fixed component of the rotational drive unit (27) to the front end, while two ball bearings (29) are placed in contact with the outer edge of the guide ring (3), and it is made so that the air bearing type work holder of the present invention will not be swung around by the rotational force of the faceplate (28). However, at this point, a misalignment of the center of rotation of the guide ring (3), which is governed by the two ball bearings (29) attached to the arm (30) and the outer edge of the guide ring (3), and the center of the rotational drive shaft (2) and a difference in angle between the centers of rotation of the rotational shaft of the faceplate (28) and of the rotational drive shaft (2) will occur, but because the bellows coupling (9)

has elasticity, the workpiece (24) settles on the top of the faceplate (28) and rotates smoothly.

The following is an explanation of the adjustment of pressure on the workpiece (50). When air is introduced into the air pressure induction unit (1), because the clearance in all of the air pockets (5), (6), (7), (8) is the same, the amount of air flow is roughly equal, and there is no fluctuation in pressure. Although air at roughly the same pressure flows to the pressure control opening (12), since it is possible to adjust the flow with the speed controller (42) while observing the pressure gauge (38) connected to the pressure control opening (12), it is possible to adjust the pressure inside the pressure control opening (12), or the bellows coupling (9). Also, if the pressure at the inlet is P_1, and the volume is V_1, and the pressure at the outlet is P_2 and the volume is at V_2, when the pressure control opening (12) is opened according to Boyle's Law, $P_1V_1 = P_2V_2$, from the difference in cross-sectional area between the pressure control opening (12) and the air pockets (5), (6), (7), (8) of the air bearings, the pressure inside the bellows coupling (9) will drop to a low value of 0 kg/cm^2, but because there is internal pipe resistance inside the path indicated by arrow d for air to the pressure control opening (12), the coupling (19), the tube (17) and the pressure gauge (38), it is necessary to consider that the pressure inside the bellows coupling (9) will be slightly higher. In other words, if one desires to maintain a high pressure inside the air pockets (5), (6), (7), (8) and lower the pressure inside the bellows coupling (9) to 0 kg/cm^2, in order to lower the pressure which has risen due to the internal pipe resistance, a very small leak hole (31) can be previously formed in the work guide (4) to allow a certain amount

of air to escape. For example, if one assumes the pressure of the air pressure induction inlet (10) to be 6 kg/cm^2, the pressure loss due to the leak hole (31) to be 0.5 kg/cm^2, and the minimum area inside the bellows coupling (9) to be 50 cm^2, it is possible to adjust the pressure inside the bellows coupling (9) to 0 - 5.5 kg/cm^2, and therefore it is possible to adjust the pressure of the work guide (4) to 0 - 275 kg (5.5 kg/cm^2 x 50 cm^2).

With this application example the following effects are achieved.

(a) By using two layers of air bearings, because the coupling (14) attached to the air pressure induction inlet (10) and the tube (16) will not turn, it is possible to solve the problem of the tube (16) winding onto the rotational drive shaft (2) (from the standpoint of preventing the winding of the tube, it is possible to use two magnetic fluid seals to change the air bearing part on the inside of the double-pipe air bearings from a noncontacting structure to a directly contacting structure in order to seal the air; for this model, there is only one method for the purpose of preventing this winding).

(b) By using a two-layered structure for the air bearing, it is possible to attach a bellows coupling (9) to the air bearing unit; without reducing the rigidity of the air bearing in a radial direction or the thrust direction, it is possible to easily adjust the air pressure inside the bellows coupling (9).

(c) Through the elasticity of the bellows coupling (9), the misalignment of the work guide (4) and the rotational drive shaft (2) and the difference of angle between the rotational drive shaft (2) and the center of rotation of the faceplate (28) are absorbed, and the workpiece (50) will settle on the top surface

of the faceplate (28) and grinding with high precision is possible.

Application Example 2

Another application example of the present invention will be explained through Figure 2.

This mechanism is composed of an air pressure induction unit (1), a rotational drive shaft (2), a guide ring (3), a work shaft (4) and a bellows coupling (9). Air pockets (5), (6), (7), (8) (with a clearance of 0.02 mm), which form the air bearings, are formed between the air pressure induction unit (1) and the rotational drive shaft (2), and between the guide ring (3) and the work shaft (4), and the rotational drive shaft (2) and the guide ring (3) are connected through the bellows coupling (9).

The work shaft (4), which has the workpiece (50) fixed by adhesion to the bottom, has a collar on its uppermost part, forming a piston.

An air pressure induction inlet (10) and a pressure control opening (12) are fitted to the air pressure induction unit (1). A coupling (13) and a tube (16) are fitted to the air pressure induction inlet (10), and air delivered from the air supply source (15) is enclosed inside.

The enclosed air is separated into that which is expelled to the outside of the mechanism through the air pockets (5), (6), (7), and that which goes to the relay opening (11) of the guide ring (3) through the path indicated by arrow a, the coupling (14) and the tube (18). The air which is enclosed inside the relay opening (11) is again divided into the paths indicated by arrows b and c. The air which flows through path b functions as the air

bearing guide for the work shaft (4), and it is expelled to the outside through the leak holes (31) and the arrow d. The air which flows through path c is expelled to the outside through the air jacket (24), the delivery outlet (39), the coupling (21), the tube (23) the path e, the coupling (19), the tube (17) and the dial regulator (38).

In other words, by adjusting the amount of air being expelled by observing the pressure on the dial regulator (38) during operation, it is possible to adjust the pressure of the air jacket easily (if the flow is constricted, the pressure will rise).

A pin (25) is attached to the work shaft (4) in order to stop its rotation. An O-ring (26) is fitted to the pin (25) to prevent any metal-on-metal contact.

Also, with respect to the rotational drive of this mechanism, the rotational force of the rotational drive unit (27) is transmitted by the rotational drive shaft (2), the bellows coupling (9), the guide ring (3), and the pin (25), in order to rotate the work shaft (4), and with only the air pressure induction unit (1) in a fixed position, all of the other components will rotate on top of the faceplate (28), which is rotating at high speed.

With this application example, the following effects are achieved.

(a) It is possible to adjust the load pressure on the workpiece by adjusting the flow of the expelled air.

(b) By using the elasticity of the bellows coupling in a vertical direction, the difference in angle between the guide ring and the center of rotation of the face plate is absorbed,

and the workpiece will settle on the top of the faceplate and high-precision grinding is possible.

Application Example 3

Yet another application example of the present invention will be explained using Figure 3.

This mechanism is composed of an air induction unit (1), a rotational drive shaft (2), a work guide (4), a guide ring (3), a weight (37) and a bellows coupling (9).

Air pockets (5), (6), (7), (8) (with a clearance of 0.02 mm) which form the air bearings are formed between the air pressure induction unit (1) and the rotational drive shaft (2), and between the work guide (4) and the weight (37), and the rotational drive shaft (2) and the work guide (4) are joined by the bellows coupling (9) and the arm (39).

An air induction inlet (10) is fitted to the air pressure induction unit (1). Also, a coupling (13) and a tube (16) are attached to the air induction inlet (10), and the air delivered from the air supply source (15) is enclosed through the tube (16) and the coupling (13). The enclosed air is divided between the air pockets (5), (6), (7) and the path indicated by arrow a. The air which passes through the path indicated by arrow a is enclosed inside the work guide relay opening (11) through the coupling (14) and the tube (18).

The air which flows through the relay opening (11) is divided between the air pocket (8) and the circumferential groove (40). The air which flows to the air pocket (8) is expelled to the outside of the mechanism through the paths indicated by arrows b, c. On one hand, the air which has been channeled to the

circumferential groove (40) is introduced to the air pockets (8) of the air bearings of each separate system through the leak holes (31). In the same way, the air which has entered is expelled through the paths indicated by arrows d, e. Also, an O-ring (33) is fitted so that air will not leak above or below the circumferential groove (40), and the air is sealed. In addition, the work guide (4) and the guide ring (3) are firmly fixed by screws (41).

A rotational drive unit (27) is fitted to the upper part of the rotational drive shaft (2), and it is completely joined to the rotational drive shaft (2). Therefore the rotational force transmitted from the rotational drive unit (27) will also rotate the guide ring (3) through the bellows coupling (9), the arm (39), the work guide (4) and the screws (41). The air pockets (5), (6), (7) of the air bearings are between the air pressure induction unit (1) and the rotational drive shaft (2), and because they are in a noncontacting state, the rotational force is not transferred. In other words, only the air pressure induction unit (1) will remain stationary through the tube (16) suppressing the rotational force, and all of the other components will rotate on top of the faceplate (28) which is rotating at high speed. The weight (37) has the workpiece (50) fixed through adhesion to the bottom, and while revolving along with the work guide (4), it can move easily in a vertical direction along the air bearing guide. Also, in order to stop the rotation of the weight (37), a pin (25) is fitted to the arm (39). An O-ring (26) is fitted to the pin (25) to prevent any metal-on-metal contact.

With this application example, the following effects will be achieved.

(a) By using the elasticity of the bellows coupling (9), the angular difference between the centers of rotation of the rotational drive shaft (2) and the faceplate (28) is absorbed, the workpiece (50) will settle on top of the faceplate (28), and high-precision grinding is possible.

(b) The weight (37) to which the workpiece (50) is attached, while rotating along with the guide ring (3), will easily move in a vertical direction.

Effect of the invention

Through the application of the present invention, the following effects will be achieved.

(a) Because it is possible to adjust the air pressure inside the bellows coupling easily, it is possible to change the pressure of the workpiece on the faceplate freely and quickly, and it is possible to carry out an effective grinding of the workpiece with a wide range of characteristics to the finished surface.

(b) Because the workpiece will become stably positioned while being ground, it is possible to prevent umbrella-shaped grinding in which the height increases toward the center of the workpiece due to misalignment of centers of rotation or angular differences. For this reason, the occurrence of defective products will be eliminated, and the grinding of workpieces with a high degree of surface precision is possible.

(c) The grinding of workpieces with various thicknesses are possible, and the previous process of adjusting the thickness of each workpiece through a planing process becomes unnecessary,

making it possible to reduce the time and labor by a large degree.

(d) Because the work holder has an independent structure, it is possible to grind different materials with differing grinding properties, such as Si and Al_2O_3 at the same time.

Brief description of the figures

Figure 1 is a cross section which shows an application example of the air bearing type work holder of the present invention, Figure 2 is a cross section of another application example of the present invention, Figure 3 is yet another application example of the present invention, and Figure 4 is a cross section of a work holder of the prior art.

(1) Air pressure induction unit
(2) Rotational drive shaft
(3) Guide ring
(4) Work guide
(5), (6), (7), (8) Air pockets
(9) Bellows coupling
(10) Air induction inlet
(11) Relay opening
(12) Pressure control opening
(13), (14), (19), (20), (21), (22) Couplings
(15) Air supply source
(16), (17), (18), (23) Tube
(24) Air jacket
(25) Pin
(26), (33) O-ring

(27) Rotational drive unit ..
(28) Faceplate
(30), (39) Arms
(37) Weight
(38) Pressure gauge
(40) Circumferential groove
(41) Screws
(42) Speed controller
(50) Workpiece

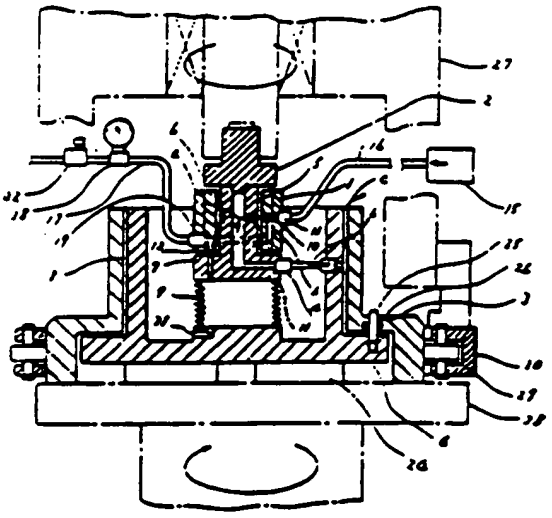

Figure 1

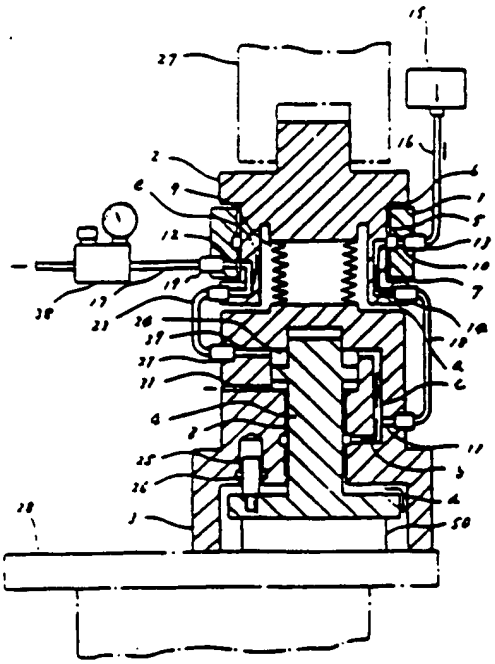

Figure 2

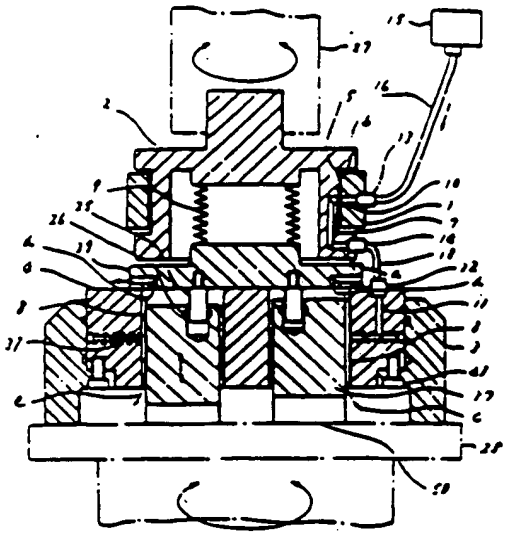

Figure 3

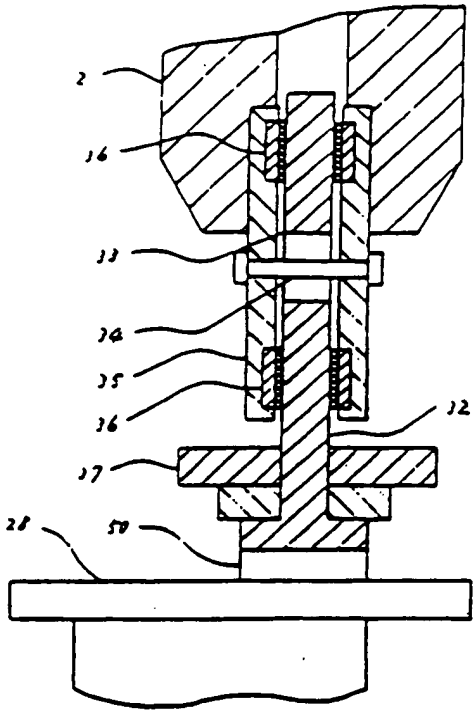

Figure 4